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ABSTRACT

It can be inferred from the corpus of misconception research that an assumption that students come into secondary and college classes with a relatively homogeneous view of the world has been made. This paper takes the position that this assumption keeps researchers from a more comprehensive understanding of the factors that lead to science achievement and positive attitudes. A person's fundamental view of reality is what is known as a "world view." The purpose of this paper is to present Michael Kearney's model of world view and to discuss its potential for use in science education research. The paper is divided into two parts, and part 1 is further divided into several sections. They include: (1) "The Concept of World View"; (2) "Root Analysis of Misconceptions"; (3) "Defining World View"; (4) "World View in Science Education Literature"; (5) "Formation of a World View"; (6) "World View and Cultural Anthropology"; (7) "The Kearney World View Model"; (8) first, second and third order universals (each treated as a separate heading); (9) "Scientifically Inclined World Views"; (10) "Application to Misconception Research"; (11) "A Research Agenda; and (12) "Summary." Part 2 is a paper entitled "The Development of an Instrument for Distinguishing Science-Related Variations on the Causal Universal of College Students World Views" including research method, instrument development, selection of items, and a summary of results of a test of the instrument on 120 freshmen at Austin College (Texas) and 88 (out of a possible 200) randomly selected scientists. The complete 17-item instrument, "Survey of Preferred Explanations," is included. (CW)

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World View Theory and Misconception Research

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The Development of an Instrument for Distinguishing Science-Related Variations in the Causal Universal of College Students' World Views

Some of the most interesting work currently being done in science education research is with scientifically misconceived ideas about the causes and mechanisms of natural phenomena, or as it is more simply referred to, misconception research. Excellent examples can be found in the papers presented at the 1983 and 1987 Cornell University seminars on misconception research in math and science (Helms & Novak), as well as in the pages of JARST and Science Education. It has been demonstrated that students do not come into the science classroom with minds "tabula rasa." Students bring with them ideas and values about the natural world that they have formulated on their own or have acquired from previous educational experiences. As scientifically acceptable explanations some of these ideas are nonsensical, others are quite close if not essentially correct. Some students come into class already holding a high view of science. Others come with value systems that will readily incorporate a high view of science given the proper circumstances. Others are prepared to resist. To date research has focused primarily upon elucidating misconceptions in various subject areas and upon instructional strategies for replacing them with accurate scientific understanding.

As in any avenue of research certain assumptions are required. Though not stated explicitly, it can be inferred from the corpus of misconception research that an assumption of homogeneity among students is being made, even when there is gender, racial, and cultural diversity among students. Specifically, it is assumed that students come into secondary and college science classes with relatively homogeneous, fundamental views of the natural world capable

of assimilating and valuing modern scientific understanding when science knowledge is presented in traditional enquiry fashion. Therefore, when misconceptions are encountered an exact identification of the misconception is sought, plus methods for supplanting it with accurate scientific understanding. Generally it is not asked, "is it possible that this scientifically misconceived idea is a logical deduction from some fundamental view of nature held by the student?" This question indicates that the researcher suspects that more is at issue than factors of pedagogy and student intelligence. This is the question I wish to ask. I want to know more about students' fundamental views of the world, even when the students by standard definitions are not considered culturally diverse. I am suspicious that the assumption of student homogeneity keeps us from a more comprehensive understanding of factors that lead to science achievement and positive science attitudes. Furthermore, I suspect that it shields us from the root causes for the documented recalcitrance of misconceptions to standard science pedagogy. Although I have begun this paper with a focus on science misconception research, I intend that it become evident that worldview theory can be applied to a number of research interests.

A person's fundamental view of reality (or nature) is what is known as a "world view." There are several reasons that the concept of world view has not often been used in science education research; but the major reason has been the lack of a theory of world view that can be used as an analytical tool. In recent years that lack has been remedied. The purpose in this paper is to present Michael Kearney's model of world view and to discuss its potential for use in science

education research. My intention is to adapt his theory of world view for use in science education research. I have not discussed the evidence that supports his theory, because he has already done that far better than I could in his book World View (1984).

Most would grant that in ethnically diverse classrooms a **prima fascia** case can be made for worldview variations as a factor in the education process. The principal assumptions in my work are that the students in most, if not all, science classrooms have subtle, worldview variations; and that these variations are an important factor in science achievement and attitude development among students. This paper differs from many others in science education research in that I assume that studies in anthropology can be as important to science education as the history and philosophy of science. Without these assumptions one would not embark on this avenue of research. Having made them, the research thus derived will ultimately speack to their veracity.

The Concept of Worldview

[My terminology is that of the cultural anthropologist. Synonyms for world view that occasionally appear in the education literature are root metaphor, world hypothesis, view of nature, view of reality, and perceptual framework. Also, I use "world view" as a noun and "worldview" as an adjective.]

The concept of world view is often associated with civilizations, religions, and eras (see Quigley, 1961). One speaks of a Western world view, an Eastern world view, medieval world view, or scientific world view. Americans have difficulties understanding the problems of

the Near East because the modern, Western world view is so different from the traditional, Islamic world view. In fact, awareness of world view is most acute when we step out of our own culture and into another.

With the rise of modern science came a new way of looking at the world. The modern scientific world view is a uniquely Western phenomenon born out of the intellectual tumult of the 16th to 18th Centuries in Europe. With the rise of Newtonianism a mechanistic world view triumphed over its competitors, the Aristotelian, "world as an organism" view, and the Neo-Platonic, "mysterious universe" view (Kearney, 1971). The triumphant mechanistic view exemplified by the philosophical arguments of Rene Descartes and the experimental work of Newton and Boyle became the basis of modern science. It is a reductionistic view that sees the explanation of the whole in the parts, where machine-type analogies are considered appropriate for explaining natural phenomenon. And though modern physics is modifying the classical scientific world view, it remains a thoroughly empirical view that stresses the importance of testable hypotheses concerning natural causes. In modern America, a primary goal in science education is the development of a scientific world view, especially with regard to scientific ways of thinking.

Since its birth the phenomenon of modern science and its attendant world view have slowly spread beyond European borders. In 1967, George Basalla presented a three-stage model that describes this expansion and growth of science in nonscientific societies. In a new area, science is at first dependent upon older science and scientists. For example American science was for many years dependent

upon European science. Basalla suggested that for the new science to become independent, seven tasks needed to be completed. The first task and the one most pertinent to the subject of world view is that a,

> "resistance to science on the basis of philosophical and religious beliefs must be overcome and replaced by positive encouragement of scientific research" (p. 617)

While philosophical and religious beliefs are not identical with world view, because they are so intimately linked with world view (they are an important part of the content of a world view), we may conclude that the emergence of an independent science requires a scientifically compatible world view. The people of nonscientific, nontechnological societies often have world views that are incompatible with scientific thinking. It is not that they are nonrational (Horton, 1967), but that their rationality based on a different world view results in a nonscientific way of thinking. For such a society to develop an independent science, the world view of a significant portion of its people must change.

Figure 1 graphically represents world views in scientific and non-scientific societies. As examples we may take respectively the United States and a non-Western, developing nation (assume equal population sizes). The X-axis represents a hypothetical scale of worldview compatibility with scientific thinking. The Y-axis represents the hypothetical frequencies of the scientifically compatible world views in the two example nations. At first one might think that the worldview frequency distribution for a scientific society such as the United States should be drawn with less variation. However, the United States is a pluralistic nation, and is becoming more so. The

historic American subcultures of Blacks, Native American Indians, and women are all under-represented amongst science students and in science-related occupations. Other subcultures have been transplanted from nonscientific societies. Furthermore, throughout the whole of American society there is significant interest in decidedly unscientific practices such as astrology. Taken together, this suggests worldview variation even within what is normally considered a scientific society.

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INSERT FIGURE 1

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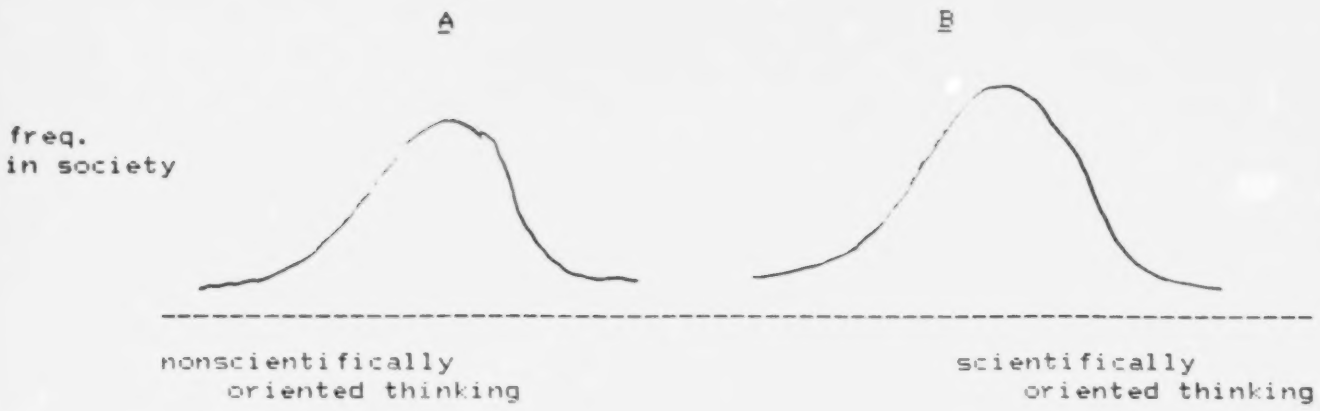
Figure 1 helps us to see that a primary task among developing nations is shifting the distribution of worldview variations sufficiently toward scientific compatibility so that the society can sustain independent science. For the United States the task is much different. Given the basic science education goal of developing within students a scientific worldview, many would argue that the American education task is to move the distribution center further to the right, while simultaneously reducing heterogeneity. This presupposes that the current, dominant scientific world view is the best one for supporting the scientific enterprise. Others disagree and seek through education the reconstruction of the scientific world view in different modes, e.g., a feminist mode (Coughlin, 1984).

Graphic Representation of world view
in Scientific and non-Scientific Societies



A = nonscientific society
B = scientific society

Fig. 1

Another view of the American task presupposes nothing about the current, dominant scientific worldview. Instead, the task is to build bridges between the enterprise of science and the worldview variations within the populace. That is the position taken in this paper.

Root Analysis of a Misconception

The relevance of worldview theory is most easily seen in misconception research. In a typical misconception study the researcher might investigate students' understanding of the concept "ecosystem" by asking students why some organisms consume other organisms in a given pattern or sequence. Responses such as "it's God's purpose" and "organisms eat other organisms to preserve their species" are considered misconceptions (Marek, 1986). The researcher might then attempt to displace the misconceptions by employing Ausubelian cognitive bridges, i.e., the introduction of a lesson using statements intended to connect new material to what the students already know (Ausubel et. al., 1987). Such attempts to make learning more meaningful do help, but to date research shows the effects to be limited. Based on worldview theory, one can argue that misconception is a more complicated phenomenon than previously considered, and that cognitive bridges as currently construed will never be completely effective.

Figure 2 shows two distinct categories of misconception. The first category is the relatively simple case of uninformed naivete, inadequate instruction or misinformation that leads to factua. misunderstanding. In this category the student's worldview is not the issue. This is the general assumption in current misconception research.

However, worldview theory points to a second category. A misconception can be an explanation logically deduced from an alternative world

view. Because this misconception has intuitive appeal for the student, assimilation of what is considered proper scientific understanding is hindered. Or, a student may have an alternative world view which in principle is capable of assimilating scientific understanding, but does not esteem scientific explanations of physical reality. Thus, the student does not retain them. Third, though a student's alternative world view might not actively hinder science understanding or interest, meaningful learning requires that the science concepts be linked to the student's world view. The failure to establish such links results in the rejection or non-retention of the science concept.

In the second category, the student's ideas are not properly called "misconceptions," fore they are logically grounded in the student's view of nature. They are alternative conceptions, only some of which are also "science" misconceptions. Take the example of the student who responds, "it is God's purpose." For this student the teleological why is apparently more important than secondary, mechanistic, causal factors. A great injustice is done to the student by labeling this response a misconception.

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INSERT FIGURE 2

****

Defining World View

World view refers to the culturally-dependent, generally subconscious, fundamental organization of the mind. This organization manifests itself as a set of presuppositions which predispose one to feel, think, and act in predictable patterns. Kearney refers to world view as:

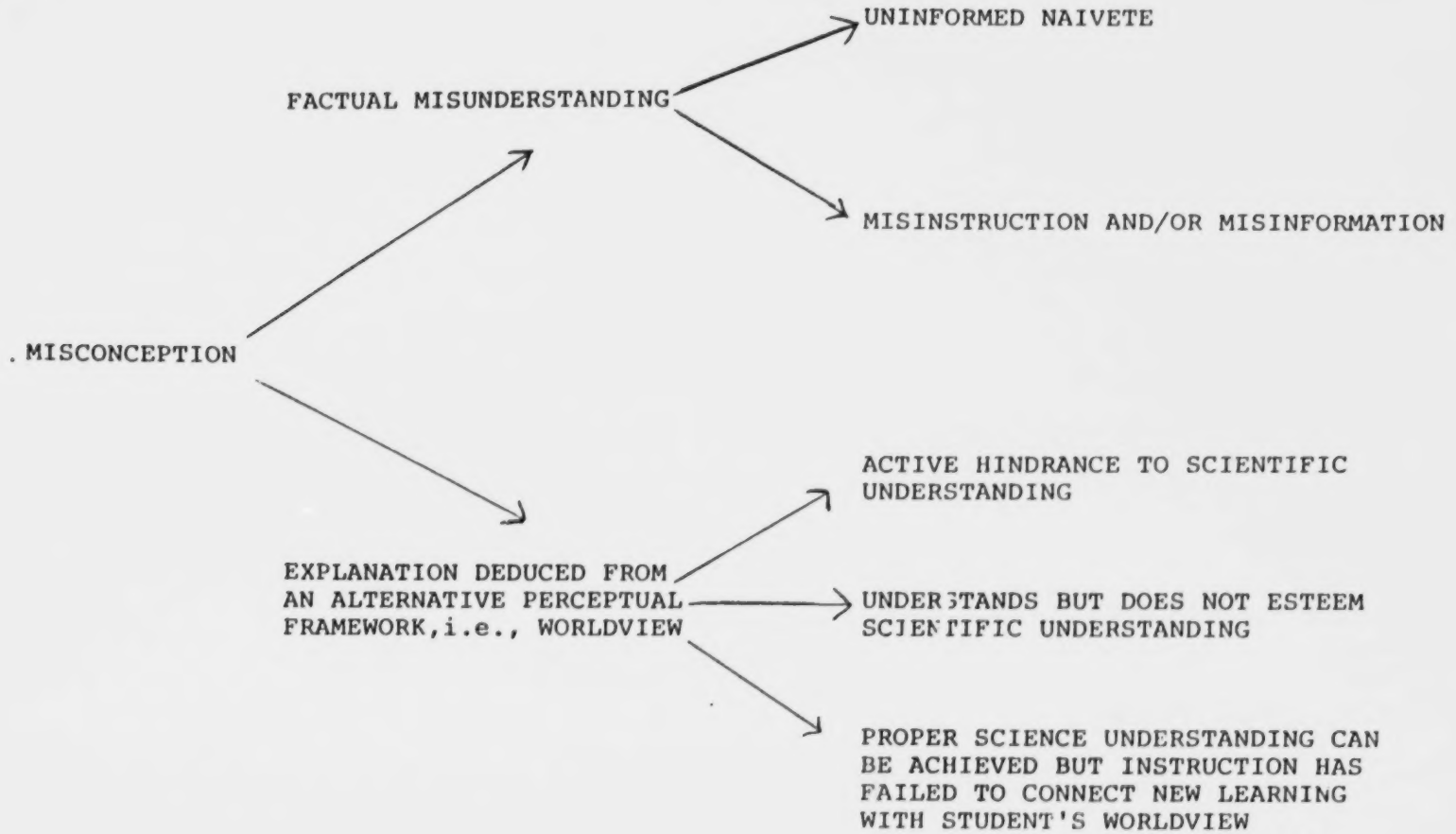
UNINFORMED NAIVETE
FACTUAL MISUNDERSTANDING
MISINSTRUCTION AND/OR MISINFORMATION
MISCONCEPTION
ACTIVE HINDRANCE TO SCIENTIFIC UNDERSTANDING
EXPLANATION DEDUCED FROM AN ALTERNATIVE PERCEPTUAL FRAMEWORK,i.e., WORLDVIEW
UNDERSTANDS BUT DOES NOT ESTEEM SCIENTIFIC UNDERSTANDING
PROPER SCIENCE UNDERSTANDING CAN BE ACHIEVED BUT INSTRUCTION HAS FAILED TO CONNECT NEW LEARNING WITH STUDENT'S WORLDVIEW

FIGURE 2

> "...culturally organized macrothought: those dynamically interrelated basic assumptions of a people that determine much of their behavior and decision making, as well as organizing much of their body of symbolic creations ... and ethnophilosophy in general." (1984, p.1)

To be rational means to think and act with reason, or in other words to have an explanation or justification for thought and action. Such explanations and justifications ultimately rest upon one's world view, one's presuppositions about the world. Or in other words, a world view inclines one to a particular way of thinking. According to Kearney (1984, p.41) a world view:

> "...consists of basic assumptions and images that provide a more or less coherent, though not necessarily accurate, way of **thinking** about the world." (emphasis added)

Specifically, a world view defines the self. It sets the boundaries of who and what I am. It also defines everything that is not me, including my relationship to the human and non-human environments. It shapes my view of the universe, my conception of time and of space. It influences my norms and values (Kraft, 1978, p.4).

Often one thinks of a world view as religion or philosophy, for example the Christian world view or the realist world view. However, religion and philosophy are the specific content or a world view. They are the visible expressions of a world view (Hiebert, 1976, p.371). In Wallace's descriptive prose:

> "...a world view is not merely a philosophical by-product of each culture, like a shadow, but the very skeleton of concrete cognitive assumptions on which the flesh of customary behavior is hung. World view, accordingly, may be expressed, more or less systematically, in cosmology, philosophy, ethics, religious ritual, scientific belief,and so on, but it is implicit in almost every act" (1970, p.143).

According to anthropologists the assumptions that compose a world view have five functions (Kraft, 1974). They explain the how and why of

things, and why things continue as they do. They validate "...goals, institutions, and values of a society and provides them with a means for evaluating all outside influences as well as activities and attitudes within the society" (1974, p.4). They reinforce people "...at points of anxiety or crisis in life providing security and support for the behavior of the group " (1974, p.5); and both encourages and prescribes behavior.

Forth, worldview assumptions function as integrators. "This system makes it possible for a people to conceptualize what reality should be like and to understand and interpret all that happens day by day in this framework" (Kraft 1974, p.5). Our sense perceptions are ordered and systematized. Finally, there is an adaptation function. A world view is "...resilient and reconciles differences between the old understandings and the new in order to maintain a state of equilibrium" (1974, p.5). A world view helps one maintain a sense of mental order and balance in a world of change via the dialectical interaction between our extant worldview assumptions and environmental changes.

Cultural anthropologists study world views because they want to know more about people and their cultures. They want to know why one group acts and thinks this way, while another group acts and thinks a different way. For educators the importance of world view is identified in two assumptions:

> "that the best immediate understanding of behavior is offered by understanding the thoughts that underlie the behavior," and
>
> "...other things being equal, the economy of human thought and the nature of culture are such that cognitive assumptions at work in one area of life, say economic production, will also organize thinking in others, say ... ideas about human nature." (Kearney, 1984, p. 3,4)

In other words we assume that what we think has a great influence on our actions; and furthermore, that even very different areas of thought are influenced by what might be called generic, cognitive assumptions. Knowing something about students' worldviews should enable an educator to better understand student attitudes, achievement and behavior in the classroom.

The Formation of a World View

The driving force behind the development of a world view is our need to relate to the outside world. As aptly stated by Ross (1962, p.x), man's "...experience is useless unless interpreted..." Therefore, beginning in childhood, each person interacts with his or her physical and social environment, and virtually unconsciously through this myriad of environmental interactions, worldview assumptions are constructed. The process occurs over a long period of time, with the formative, childhood years being of most importance. Through the years of schooling, formal education contributes to worldview development; and in turn, a world view provides a foundation upon which cognitive frameworks are built during the learning process.

At some point of maturity (e.g., as an adult) the malleableness of a world view begins to decrease. It becomes resilient in the face of change providing an adult with cognitive stability. However, as noted above world views have an adaptation function which allows even adults to adjust to new environments. While worldview assumptions are strongly held, they are not immutable. The strength with which a mature world view is held appears to be inversely related to the degree of heterogeneity in a culture. The more heterogeneity, the less strongly a

world view is apt to be held. This whole process of worldview development and change is what Kearney calls "dialectical constructionism" (1984, p.3), and it shares much with Piaget's genetic epistemology (1971) as well as with Ausabel's constructionist theory of learning (1978). In human mental architecture, world view is the foundation upon which cognitive and perceptual frameworks are built. Figure 3 is an attempt to graphically show the relationship between cognitive frameworks, perception, and world view.

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INSERT FIGURE 3

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World View in the Science Education Literature

To date worldview is something only occasionally referred to in the education literature. Anderson (1988) recently has used worldview in a discussion of cognitive styles and multicultural populations, specifically referring to non-Western and Western worldviews. Duschle (1988) used the term in a discussion of the problem of scientism in science education. Only Kilbourn (1974) has used the concept in research. Noting Robert's comment that "... virtually every science teaching program tries to get youngsters to adopt a scientific way-to-explain..." (Roberts, 1972, p. 1), he preceded to analyze secondary, biology textbooks for implicit projections of world views. His method of identifying world views was based on Peppers' root metaphor theory (1942), a configurationalist approach to worldview.

With the exception of Kilbourn's 1984 article in which he summarizes his earlier work, there has been no further work similar to

The Dialectical Development & Evolution of a World View [adapted from Reese, 1994, p. 45]

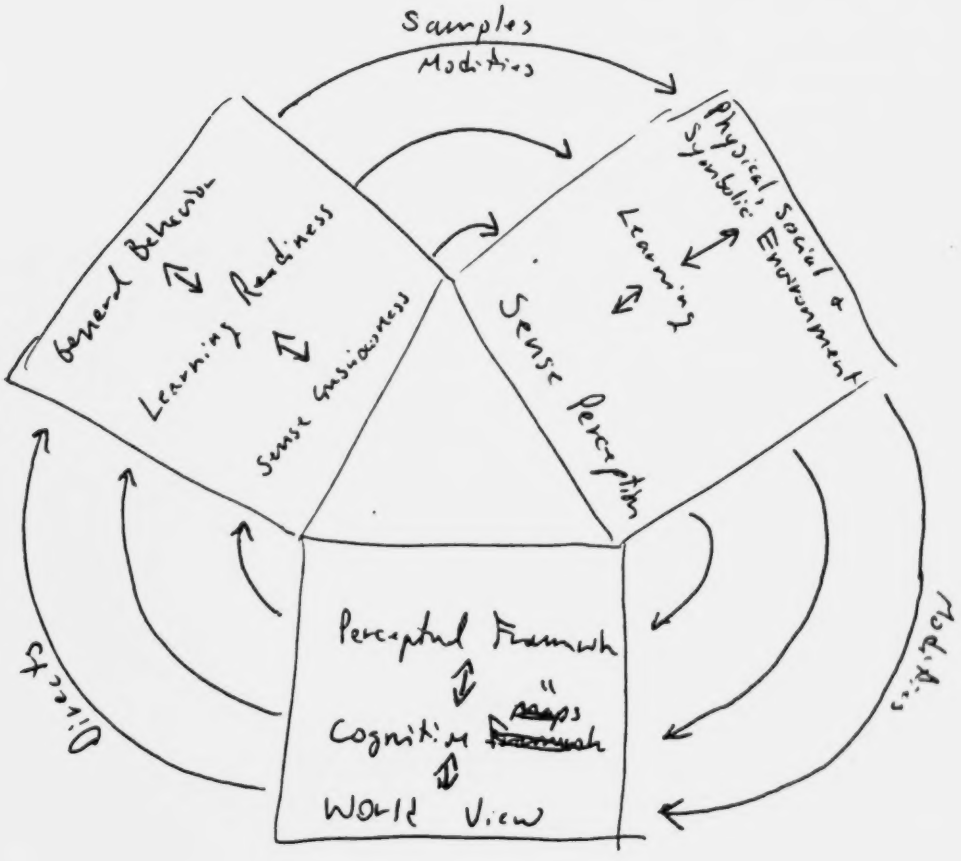

Figure 3

his textbook study nor any other education research where worldview is involved as a key construct. Kilbourn hints at the reason for this lack of research activity when he talks about the tremendous complexity of worldviews (1984, p. 36). It is too complex a concept to be of any use to researchers. Our definitions of worldview do not tell us enough. Afterall, what have we really said when we define worldview as one's "view of reality?" Is the concept any more useful if we add that a worldview "... connotes both the ontological and epistemological dimensions ..." of one's orientation in the world (Kilbourn, 1984, p.35)? The vagueness of the definition is such that we have done little more than name a hypothetical entity. It is sufficient for crude analytical work such as examining a textbook (a relatively simple object of research) for general metaphysical trends, but little more. The further use of world view in education research requires a theory of world view that more articulately defines a worldview construct.

World View and Cultural Anthropology

World view is a term more familiar to cultural anthropologists and philosophers than to educators. Yet even for anthrologists the lack of adequate theory of world view is a problem. Kearney (1984) writes:

> "Although world view is one of the central subjects of American cultural anthropology, there is surprisingly little theoretical literature concerning it..." (p. 1). "Although world view is a subject of immense importance in the social sciences and philosophy, a coherent theory of world view is nonexistent" (p. 9). This lack of a conceptual framework has been one of the main obstacles to the study of particular world views and their cross-cultural assessment" (p. 1).

Michael Kearney has taken up the challenge of providing that framework. His particular goal is to define a worldview construct with sufficient articulation so that it can be used in the cross-cultural

study and assessment of world views. It is my contention that there exists in American society significant worldview variations and that these variations influence the process of education, particularly science education. Therefore, Kearney's worldview theory has important implications for educational research as well.

Kearney begins with a historical review of the concept of world view. The general paradigm used by American anthropologists doing worldview research has been that of "theme." This monothematic configuration-alist approach is an,

> "...attempt to discover and describe the underlying 'pattern,' 'configuration,' 'basic personality,' 'ethos,' or 'world view' of a society. What all of these concepts have in common is that they refer to an hypothesized mental principle that organizes in a distinctive was nonmaterial elements...of a given society. These mental constructs are assumed to shape social and cultural behavior and the material and nonmaterial results of this behavior..." (Kearney, 1984, p. 23)

Cultural anthropologists' attempts to identify underlying cultural themes fall into two traditions, one built upon the work of Franz Boas (1911) and the other Robert Redfield (1941,52). The Boasian tradition includes such anthropologists as Ruth Benedict (1934) and Margaret Mead (1920). We may take Benedict's Patterns in Culture as typical of this tradition. She felt that by careful analysis one could find in each culture a single psychological theme which fundamentally ordered each culture's world view, a premise heavily influenced by Gestalt psychology. Kilbourn's worldview study was based upon Pepper's (1942) root metaphors. Although Pepper was a philosopher who did not cite many anthropology sources, h s work nevertheless falls within the Boasian tradition.

Redfield, whose work forms the basis for the second tradtion, used Benedict's total culture approach to world view research, but he

considered it an oversimplified approach. His solution, a very important advance in worldview research, was to look at a world view as a composite of worldview universals (Kearney's terminology). His principal universals are the unitary "Self" and the tripartite "Other," composed of Human, Nature, and God. According to Kearney:

> "Redfield's concept of world view is mainly descriptive. Insofar as he speculated on the causes for differing world views he did so very generally...he did not attempt to explain why a certain type of society may have one world view, nor how world views change. Nor did he attempt to explain what connection there is between world view, environment, and behavior" (1984, p. 38-9).

Michael Kearney's work is in the Redfield tradition. His contribution to worldview research is an articulated model of world view that moves worldview research beyond the level of description to the level of analysis.

The Kearney World View Model

The Kearney model begins with the idea that a world view is an organized set of fundamental, cognitive assumptions about reality. He assumes that this organization is shapedby the,

> "... internal equilibrium dynamics among [the worldview assumptions]. This means that some of these assumptions and resultant ideas, beliefs, and actions predicated on them are <u>logically</u> and <u>structurally</u> more compatible than others, and that the entire world view will 'strive' toward maximum logical and structural consistency. The second and main force giving coherence and shape to a world view is the necessity of having to relate to the external environment" (p. 52).

In other words, he postulates that a world view tends to be internally consistent, in that assumptions are logically integrated and universals are structurally integrated. It is externally valid in that the human need to relate to the external environment fosters coherence.

Kearney's ideas are similar to Redfield's in that he suggests that all world views are a structural composite of seven, basic cognitive categories or universals: Self, Other, Relationship, Classification, Causality, Space, and Time. These universals He likens to the diagnostic categories used by physicians:

> "Although the doctor is confronted with a variety of patients, he can presumably describe the most significant medical facts about them in terms of...features common to all patients, e.g., blood pressure, pulse, respiration" (p. 65).

In principle groups of people and even individuals can be identified by worldview variations which result from the content variation in worldview universals. Logically consistent assumptions about reality are the content. Each universal is composed of a hierarchically arranged set (or sets) of assumptions, or presuppositions, at the end of which is a final assumption, or 1st order assumption, an ultimate assumption beyond which there are no others. One might think of a 1st order assumption as akin to Aristotle's final cause. At the opposite end, these hierarchies blend into the cognitive frameworks with which educators are more familiar.

Collingwood provides an amusing story in which both ends of a hierarchy are apparent:

> ".... if you were talking to a pathologist about a certain disease and asked him 'What is the cause of the event E which you say sometimes happens in this disease?' he will reply 'The cause of E is C'; and if he were in a communicative mood he might go on to say 'That was established by So-and-so, in a piece of research that is now regarded as classical.' You might go on to ask: 'I suppose before So-and-so found out what the cause of E was, he was quite sure it had a cause?' the answer would be 'Quite sure, of course.' If you say, 'Why?' he will probably answer 'Because everything that happens has a cause.' If you are importunate enough to ask 'But how do you know that everything that happens has a cause?' he will probably blow up in your face, because you have put your finger on one of his absolute presuppositions...But if he keeps his temper and gives you a civil and candid answer, it will be to the following effect. 'That is a thing we take for granted in my job. We don't question it" (1940:31-2).

At one end of the pathologist's mental framework is his knowledge of diseases and scientific research. At the other is a 1st order assumption (what Collingwood refers to as an absolute presupposition) in the worldview universal, Causality.

At this point one may wish to ask how world view and belief may, if at all, be distinguished. Beliefs seemed to be implied in the terms "Christian world view," "Islamic world view," or "secular world view." Ketner (1972) in his dissertation "An Essay on the Nature of World Views" argues that the basic worldview concepts are in fact fundamental beliefs. Kearney rejects this position citing Needham's (1972) contention that "belief" itself is "...a concept particular to the Western world" (1984:51). The arguments are rather esoteric and I do not believe that they are significant for research in education. I would only add that there is a range of consciousness with regard to worldview assumptions; and the lower the level of consciousness, the less belief-like a worldview assumption may seem. Collingwood's pathologist would no doubt consider his causality assumption to be more than a belief.

Two 1st Order Universals

"Universe" (or "cosmos") is the English language term for ultimate inclusiveness. Within the universe an individual's primary point of reference is himself or herself, i.e., the Self. The functioning of any human society is dependent upon self-identification and culturally determined notions of the nature of self (Hallowell, 1955). Every self (or a person's sense of self) exists and interacts within an environment, i.e., the Other. Thus the ultimate inclusiveness is

composed of the Self and all that is not the Self, i.e., the Other. These two are the 1st order universals and together form the principal axis of a world view (Kearney, 1984:68-70). (The adjectives 1st, 2nd, and 3rd order are my own, not Kearney's. I have added them because they help to clarify the organization of three sets of universals.) This axis can be seen in Figure 4 which is Kearney's diagrammatic summary of his model.

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INSERT FIGURE 4

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The nature of Self varies between two polar extremes. At one pole are the individuals whose Self is continuous with the cosmos. These individuals identify themselves with the Other. The distinction between Self and Other is minimal. In a sense, all is Self. At the other pole nothing is Self. For these individuals the Self has become so depersonalized that they feel they have ceased to exist. In American society we call individuals at the first pole, mystics; and at the second pole, psychotics. Piaget has argued that from birth normal cognitive development is based on the gradual, progressive elaboration of a distinction between Self and Other (Piaget, 1969).

As stated above, the Other is everything in the Universe except the Self, and can be divided into domains of equivalent taxonomic status. The simplest division is into domains of human environment and physical environment, or society and nature (see Figure 5).

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INSERT FIGURE 5

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Kearney's World View Model

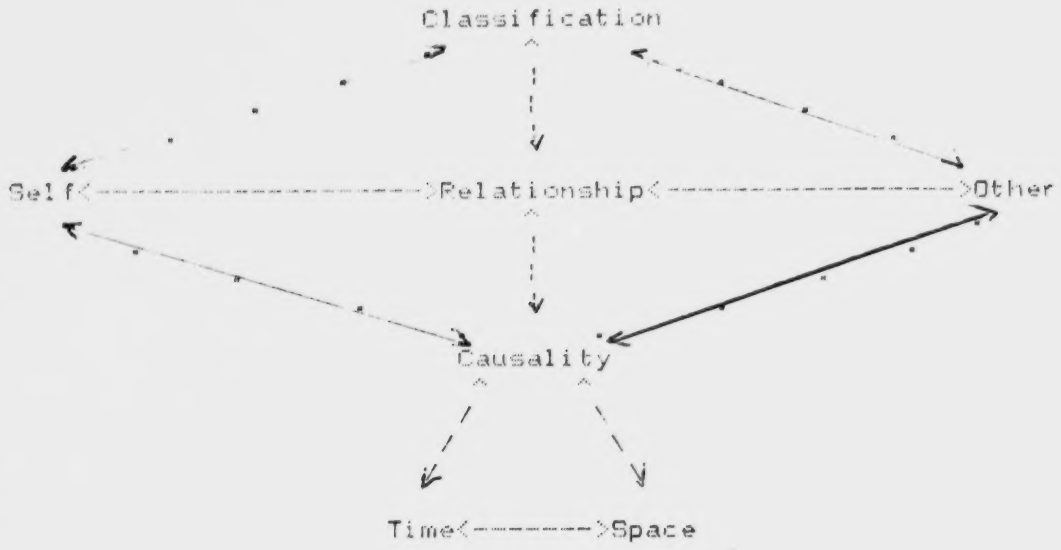

Figure 4

Self-Other Axis

Figure 5

For most people however, Redfield's tripartite division is more appropriate: Society, Nature, and the Supernatural (or God). Some of the bitterest controversies in American public education can be traced to these differences in the Self-Other axis.

Three 2nd Order Universals

One's sense of Self and Other is dependent upon the interactions between Self and Other. They are structurally integrated, thus, the first 2nd order universal is Relationship, i.e., the Relationship between the Self and Other. For example, a child raised in a warm, secure home develops a confident sense of self and knows the world (i.e., the Other) to be orderly and nonthreatening. Whereas an abused child grows up with a low self-esteem. Or, a child raised in an environment of unexpected trauma may come to see himself as a powerless being living in an unpredictable world.

Fundamentally the relationship between the Self and Other can be one of harmony, subordinance, or dominance. In actually there is likely to be mixing. For example, the Self-Other relationship with regard to the individual and society may be one of harmony, while the individual-nature relationship one of dominance (Kearney, 1984:72-8). Historically, a relationship of dominence derived from the Genesis creation accounts was crucial to the development of experimental science (Hooykass 1972, Cobern 1988). The dominence theme continues to be important in science, though not without problems (White 1962). It is implicite in locus of control research that a dominent relationship between Self and Other is better than a relationship of subordinance.

The Self-Other split is the most obvious case of Classification, the next 2nd order universal. The most obvious case of Classification is the Self-Other split. Kearney writes:

> "Within a cognitively differentiated universe the most fundamental classification categories are Self and Other; this is the reason they are treated as universal" (1984:80).

After the Self-Other classification, comes classifications with the Other domain. Figure 6 shows two Classification methods for the Other, but there are many. A third possibility is the pantheistic fusion of God and Nature as found in classical Greek thought and some Eastern religions. Yet another Classification of the Other is between the real and unreal. Figure 6 represents the Other domains for a theist and atheist.

****

Insert Figure 6

****

In this example "real" and "unreal" are attributes of the various domains into which the Other is classified, but not domains themselves. For the theist some of the content of the supernatural domain is real, but for the atheist, the entire domain is unreal. Kearney rightly points out that one must know the attributes of an Other-domain as well as the content:

> "...it is possible that two people may conceptually group...ghosts, spirits, the Devil. Knowing this grouping alone tells us little about their respective world views. However, if we know that for one person these items are grouped together as elements of folk tales and superstitions, while for another sources of sickness and sin, we gain insight into the associated dimensions of Causality and Relationship in their respective world views." (1984:82)

We could easily replace Kearney's anthropology example with ones drawn from a high school science classroom. There may well be times when a

The Attributes, Real and Unreal

Theist

Other-domains	Real	Unreal
Supernatural	God	ghosts
Nature	people	dreams

Atheist

Other-domains	Real	Unreal
Nature	people	God

Figure 6

science teacher and a student conceptually group nuclei, atoms, and molecules. The attribute of one's group is submicroscopic reality, while for the other it is simple unreality. For one it may be significance, while for the other it is nonsignificance. The science teacher and the student are each using classification categories that reflect his or her attitudes and assumptions about the nature of reality.

Kearney develops his notion of Causality, the third 2nd order worldview universal, from a Piagetian perspective (1984:84-89). Because of that and because causality is a prominent feature in science education, the worldview universal Causality is more readily understandable to educators. Kearney employs Durkheim's definition of causality:

> "The first thing which is implied in the notion of the causal relationship is the idea of efficacy, of productive power, of active force. By cause we ordinarily mean something capable of producing a certain change. The cause is the force before it has shown the power which is in it; the effect is this same power, only actualized. (Durkheim 1965:406)

Kearney believes that an individual constructs his or her world view based on the dialectical forces in one's life, that is between Self and Other, especially during formative childhood years. Therefore he incorporates in his theory Piagetian stages of development where the nature of cause and effect changes for a child with his or her growth and experience. Following Piaget, Kearney sees the Causality universal developing through periods of participation, animism, artificialism, finalism, and force (Piaget 1969).

> "...in feelings of 'participation,' there is an assumed affinity of Self with external objects...closely allied with this is the notion of 'animism,' which endows things with consciousness and life. In the third form, 'artificialism,' there is the uncritical assumption

> that objects obey will and intention, and in doing so are organized and act for the good of men...that things exist for and are organized for man is the 'finalistic' assumption. To the extent that this notion exists, the world is seen as teleological. The fifth type of adherence is the notion of 'force' or 'power,' which is attributed to things such that they make efforts as do muscles." (1884:87)

According to Piaget, mental development involves the gradual development of a mechanical view of causality in conjunction with the gradual elimination of these five notions, although adherences often continue into adulthood. The extent of the adherence is a function of an individual's ability to completely distinguish between Self and Other, i.e., "...dividing off the internal world from the external..." (Piaget 1969:246).

Kearney accepts Piaget's dialectical view of mental development and use of mental stages, and employs Piaget's adherences as aspects of the Causality universal useful for describing and comparing world views. However, he rejects Piaget's conclusions as being culturally determined. Piaget's French Swiss children developed mechanical viewpoints precisely because they were French Swiss, and not Nuer or Hausa. Taking mechanical causality as the hallmark of advanced mental development would doom the majority of the world to mental under-development. Robin Horton's paper "African Traditional Thought and Western Science" (1967) provides a powerful example of complex, formal thought in traditional people in contrast to Western, scientific thinking. He effectively blunts the ethnocentric view of mental development characteristic of many Westerners.

Science education research has been dominated by Piaget's concepts of concrete and formal thought. Inherent in misconception research is a change of focus from the concept of concrete/formal thinking to the

concept of adherences. The next step is to recognize the context which makes the concept of adherences more intelligible, i.e., world view.

Two 3rd Order Universals

The 3rd order universals are Space and Time. There are many examples of how people view space differently. Ideas about space are common differnce between urban and rural dwellers. Unlike his rural cousin, a person who lives in the city often has little practical awareness of the compass directions east, west, south, and north. For the city dweller, direction is generally a matter of uptown, downtown, left and right. On the other hand, a walk of a "short distance" for the rural dweller is likely to translate to a much longer distance for the urban dweller who is accustomed to more compact space. In the science classroom, spatial distances often are very large or exceedingly small. In either case it is not the space common to the every day experiences of most children; hus an important aspect of science education for young children is the enrichment of their notions about space.

Time, the second 3rd order universal, is a more complicated structure. Within a world view Time can have one of three basic orientations: past, present, and future. Each of these is a different first-order assumption. Historically there has been a strong future orientation among white Americans, which in part can be traced to Puritan and Calvinistic influences in Colonial America. Certainly success in school requires such an orientation. Kearney notes that a future orientation is "...compatible with scholastic achievement in that such a student is more able to resist immediate distractions and focus energies toward...good grades, degrees, etc." (1984:95).

Kluckhohn and Strodbeck (1961) note that Spanish-Americans are much more present-oriented, in contrast to the future-orientation of many Anglos. The here and now is more real than anything that may happen tomorrow. The false stereotype of the unreliable Latino can be traced to this very different cognition of time. A worldview Time universal can also be past-oriented. Kluckhohn and Strodbeck note that this is the case with both the Chinese and Mormons. Time oriented to the past is manifested in ancestor worship by the Chinese and the Mormon interest in genealogies "...by which they attempt to discover spiritual links with unknown ancestors" (Kearney 1984:97).

In addition to orientations of time, there are different images of time. Some people have an oscillating image of time where time either runs in circles or zig-zags. According to Kearney:

> "The essential feature of this image of time is that time is seen as rhythmically swinging back and forth between recurrent markers. Such an image occurs most strongly in technologically simple preliterate societies." (1984:99)

Alternatively, the image of time can be linear, like a timeline that a history teacher might use. Time moves from the past into the present and on into the future, one-way and irreversible. And since time that has past cannot be recovered, and the present also will soon be gone, it behooves one to look to time yet to come. In other words "...a linear image of time is structurally compatible with a future orientation" (Kearney 1984:101). The co-occurrence of these first order assumptions is common in the West, and can be traced back through the Judeo-Christian tradition to the early Hebrews. In Genesis there is a specific creation event from which time starts. It proceeds through Jewish history looking toward the coming of Messiah. The Christian tradition adopted the Jewish sense of history, except that for

Christians time points toward the second coming of Messiah and the culmination of all time (Cobern 1988). These first order assumptions in the Time universal formed an important distinction between the Medieval world view and the world view of Classical Greece and Rome; and were crucial for the development of modern science in Europe (see Foster, 19 , Klaaren, 19).

In addition to the orientation and image assumptions in the Time universal, there are some important attributes (Kearney, 1984:102-106). Time can vary in depth or range. For example, the future can be a few months, a few years, or a few decades. One likely consequence is that short-range planning is preferred by those who have "shorter" futures. Another attribute is pace. For some people time walks; for others, it runs. If it runs, there is a greater need for the precise measurement of time. Furthermore, faster time generally occurs in a world view along with linear and future-oriented time.

I have already mentioned that a future orientation serves a student well. I conclude this discussion of time by noting that in the science classroom, time has further importance. The methods of science are such that time has a very specific meaning and is used with great precision. One can easily see how a student's non-scientific notion of time could render meaningless many aspects of science.

At this point one might suggest that the universals Space and Time are actually no more than attributes of the Other. Certainly, Space and Time are always thought of in conjunction with some aspect of the Other. However, unlike the attribute "real/unreal," some fundamental form of space/time cognition is common to all people (Kearney 1984:89-92). Note that in Figure 4, Causality bridges Relationship on one side,

and Time and Space on the Other. Our understanding of Causality is dependent upon both the Relationship between the Self and Other, and upon our cognition of Space and Time. These four universals are intimately related (pp. 89-107). In other words, only with some notion of space and time, plus some notion of how we relate to the external world, does a sense of Causality become conceivable.

I stated earlier that the primary difficulty with the Boasian and Redfield worldview traditions was oversimplification. Their approaches did not facilitate analytical research, but were used primarily for description. Even at that, the configurationalist approach to world view glosses over many differences. There is some truth in the statement that the Western world view is mechanistic, but there are many degrees of mechanism and many interactions with other factors. Kearney's theoretical model with its seven interacting universals, provvides the analytical tool for studying world view at the individual level and for studying subtle worldview variations, without sacrificing the ability to draw broad generalizations about world view in a society. If we see similarities in the Causality univesal then we may agree with Pepper that the West has a mechanistic world view. However, our model with its six other univesals keeps us from glossing over substantial worldview variations.

Scientifically Compatible World Views

At this point I would like to suggest that speaking of a scientific world view is to make a configurationalist statement which really does not tell us much. Nor do we say much more by substituting mechanical for scientific. We still have a monolithic view that glosses over

substantial differences. With Kearney's world view model one can develop a more detailed, and thus more accurate, picture of a scientific world view.

If we take Kearney's position that world views are composed of seven integrated universals, it readily becomes apparent that there can be many world views, each of which is scientifically-compatible. Consider an American scientist and an Indian scientist. While we may be tempted to say that they both have the "scientific world view," in fact their world views will be quite different. This is illustrated by the two frequency graphs in Figure 7. Let us assume that there are worldview assumptions and attributes pertinent to science. Figure 7-a is a hypothetical frequency distribution of Indians and Americans on a hypothetical measure of these pertinent assumptions and attributes. Our scientists would appear far to the right indicating the presence of these science-related assumptions and attributes. By this indicator the two scientists are similar and many would say they have a scientific world view.

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INSERT FIGURE 7

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Now consider Figure 7-b which is a hypothetical frequency distribution of Americans and Indians on a hypothetical measure of Eastern assumptions and attributes. The American scientist would fall on the left along with most Americans, scientist or not. While elements of his world view may be similar to elements of an Indian world view, overall he is a Westerner. The Indian scientist however, will fall to the right reflecting his Indian background. It may well be that

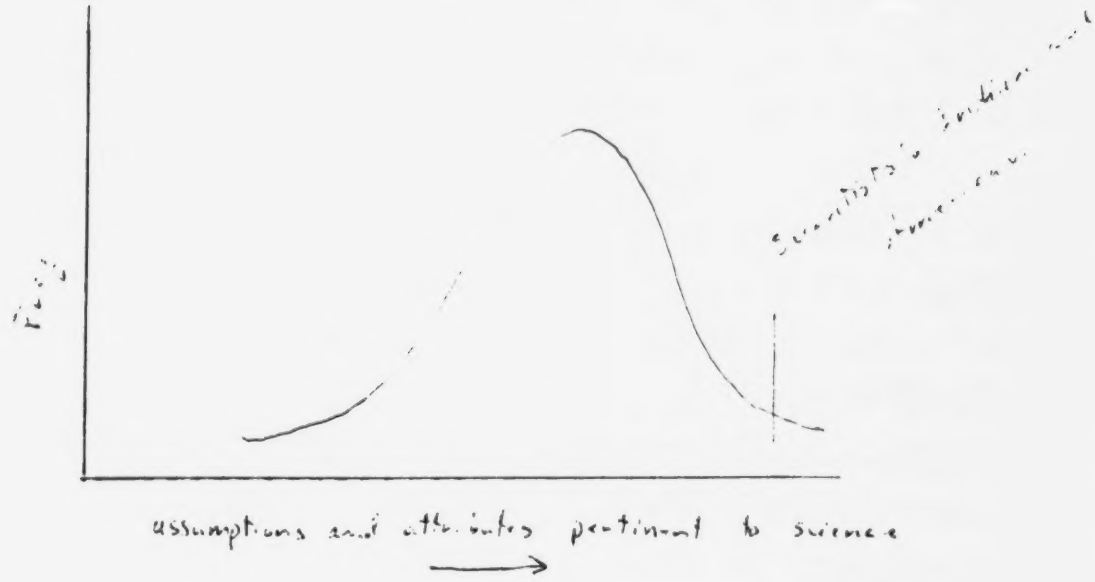

Figure 7-a

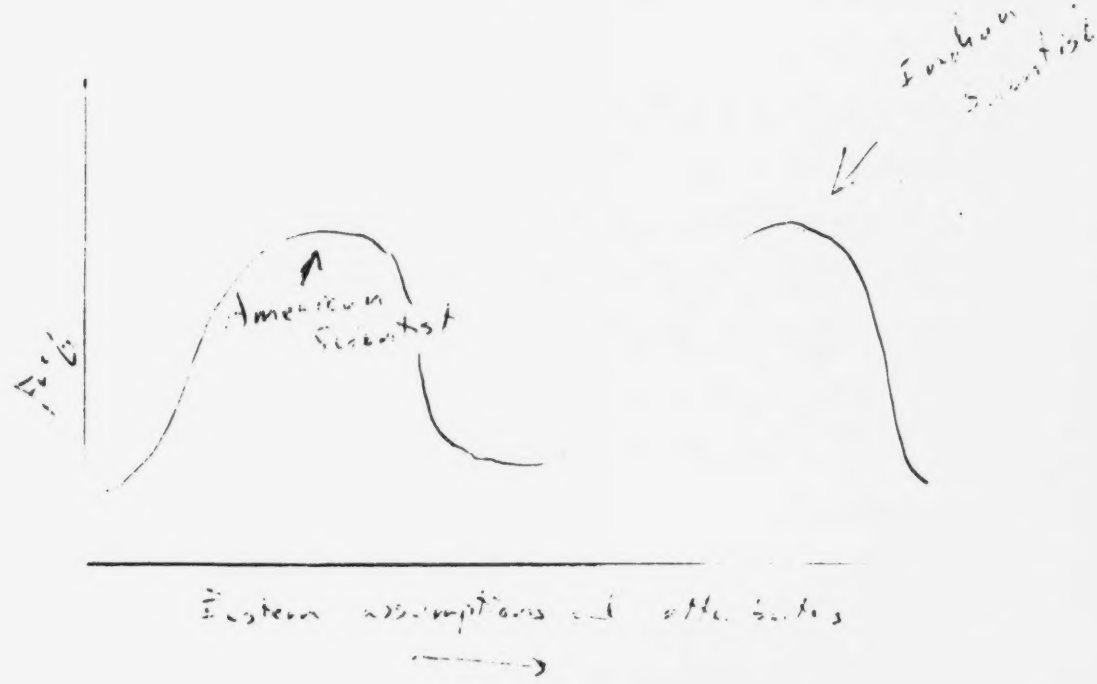

Figure 7-b

his scientific training has changed some of his Indian assumptions. To the extent that this has happened, he would fall more to the middle of Figure 7-b; but a significant difference would still remain between the two scientists.

Therefore, according to Kearney's model we should not expect one, single scientific world view. There will be content within the seven, worldview universals that is fairly constant within a group of people considered to have a "scientific world view." This is content pertinent to the enterprise of science. There will also be content differences. Depending on a person's background those differences may be rather large, as would be likely between Indian and American scientists, or rather small, as would be likely between two American scientists.

That the differences between any two American scientists are small is a result, first, of being born and raised in America. Second, the two probably will be white males from middle class backgrounds. Furthermore, they also will have had their science-inclinations developed through years of similar schooling experiences. However, the worldview variations among all high school and college students will be much greater. Major variations stem from racial, ethnic, gender, and religious differences, as well as economic class, geography, and family-type differences. These are potential, significant influences in science education.

This leads us to the questions, "what are the assumptions and attributes of a scientifically-compatible worldview?" "what assumptions and attributes are scientifically-neutral?" and "what assumptions and attributes actively hinder scientific understanding and science

attitudes?" Obviously the answering of these questions would be a significant undertaking. At this point, as an example, I will only attempt a partial answer to the first question.

Collingwood's pathologist provides an example of a necessary first order assumption in the Causality universal if a world view is to be science-inclined. The assumption is that all effects, E, have causes, C. This assumption is modified by an interaction with a first order assumption in the Classification universal, i.e., there are different classes of cause. The pathologist undoubtedly recognizes several classes and to these classes he will apply attributes such as "usage." Because he is a pathologist we can be sure that of the various classes of cause he assumes always to exist, he considers some to be appropriate for science and others not. Eventually this avenue of reasoning leads to an informational level where the pathologist has stored knowledge of specific causes for specific effects, e.g., virus X causes disease. This is a much narrower, more defined level of mental structure than the level of universals at which we began. The work on meaningful learning by Novak ( ) and Ausubel ( ) concerns cognitive structures at this level of an individual's total mental framework. However, a science-inclined world view does not require the lower, informational levels. It requires that assumptions and attributes be in place so that when specific information is confronted, such as the effects of viruses, the information will be meaningful.

While the above example speaks of science knowledge, it could as well have been science processes, or what is often called scientific thinking. Briefly, in the universal Causality our pathologist has a first order assumption concerning ways of knowing. There will be an

interaction with Classification and the result will be a category of knowing that is appropriate for science. In that category will be the knowledge that the scientific way of knowing involves observation, theory, experiment and so on.

Before leaving this section I need to say that the example of cause and effect may trouble some readers. Some would argue that cause-and-effect causality has disappeared from modern physics. In response I would say that even if we grant that this is an accurate statement about causality in the study of physics, the rest of science still lives in a Newtonian universe. Furthermore, it would be difficult to conceive of a science education program that was not based on the notion of causality. The banishment of Newtonian cause-and-effect causality would itself indicate a significant worldview shift in the general American populace.

The thrust of this section is that the Kearney worldview model leads science education researchers to three significant questions, "what are the assumptions and attributes of a scientifically-compatible worldview?" "what assumptions and attributes are scientifically-neutral?" and "what assumptions and attributes actively hinder scientific understanding and science attitudes?" The significance of the questions is that the answers have the potential to improve our understanding of what is and is not a science misconception, to improve our definitions of appropriate scientific attitudes and improve our attitude research approaches, to better inform locus of control studies, and to in general, provide a broader, more coherent framework for cognitive studies.

My example answers in this section are notably incomplete, and serve only to illuminate the questions. A complete set of answers will likely come through the study of the various models used in extant science education research on science attitudes and the nature of science. However, this research relies heavily on works the philosophy of science. worldview theory will require that researchers pay more attention to studies in the history and sociology of science as they seek to answer these question.

Application to Misconception Research

Kearney's seven, worldview dimensions allow for more variation and thus more accuracy than the thematic conception of world view. This sensitivity to variation also allows one to analyze variation within a worldview group, and thus its usefulness in education research. Given the examples in the previous section, one can begin to see how worldview theory can be applied to science misconception research. In this section I want to take up this issue explicitly.

Earlier I gave an example of misconception research in which a researcher investigates students' understanding of the concept "ecosystem" by asking them why some organisms consume other organisms in a given pattern or sequence. Responses such as "it's God's purpose" and "organisms eat other organisms to preserve their species" are considered misconceptions (Marek, 1986). However, worldview theory also can be used to explain these responses, and with more depth.

Consider first what occurs in the classroom. Based on Kilbourn's 1974 study of biology textbooks, we can reasonably assume that the typical biology classroom environment will project a mechanical world

view. This means something very specific for such worldview universals as the Other, Causality, and Classification. The physicist, Richard Bube's structural diagram of the universe (Figure 8) is a convenient way of showing the Other broken down into several Classifications, or subdomains (most of which could be further subdivided). Biology instruction primarily involves the Classifications of Cell, Plant and Animal. Some of the other Classifications in Figure 8 may also be involved on occasion, but certainly not the outer most Classification. In other words, biology instruction is functionally atheistic.

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INSERT FIGURE 8

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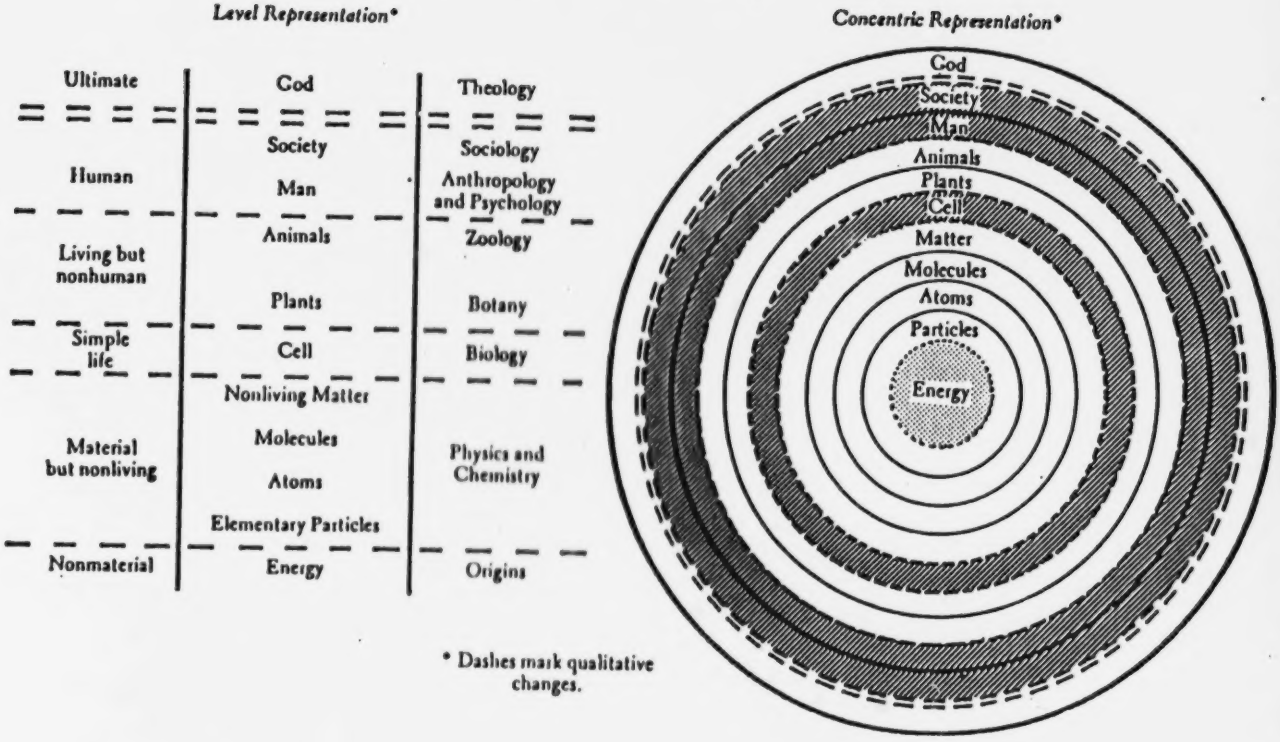
Furthermore, in the classroom the teacher will employ a rather restricted definition of cause. We say that we can explain (i.e., give the cause) an event E when we know that event E occurs only when the material conditions C occur, where the conditions C are a restricted set of Classifications within the Other domain (Ross 1962, p.64). Again, the instruction is functionally atheistic.

Turning now to the student's response, "it's God's purpose," we can infer that his world view differs significantly from the mechanical world view projected in the classroom. The Classifications important to this student are the very ones deliberately shunned in the classroom. The student's perception of the world includes the supernatural both as a Classification of The Other and as a causal agent. In Aristotelian terms, the student's interest is in final causes, not the efficient causes of biology instruction.

THE STRUCTURE OF THE UNIVERSE



Richard Bube, The Human Quest, 1971.

The same can be inferred about the student who responds, "organisms eat other organisms to preserve their species." The difference is that this student apparently knows that siting God as a causal agent is not appropriate. He has moved one step away from final causes toward efficient causes. Yet he too is using a Classification not found in the classroom in that he appeals to teleology. As it is our students may well learn from classroom instruction that big fish eat little fish, but their own world views provide the explanation.

Novak (19**, p.497) states that "meaningful learning occurs when new information is linked to existing relevant concepts in the learner's cognitive structure." Advance organizers are intended to provide such links. However, the typical advance organizer is a product of the mechanical world view and thus would be of limited value in this example. To be effective an advance organizer would have to link instruction with appropriate assumptions within the student's world view. In this example the teacher would have to introduce a greater range of Classifications, discuss their relations, and the reasons for limiting them in the science classroom. In this example the goal is not to substitute classifications since there is no indication that the students' world views actively hinder science learning. The teacher's goal would be to enrichen the students' world views by developing or refining worldview classifications.

The above scenario will have to be justified by research. It does have much that is appealing. From worldview theory we can infer detailed, testable explanations for the answers given by the students. We can infer explanations for the ineffectiveness of typical, science instructional strategies with these students. Finally, we can infer

that deep cognitive bridges that reach back to the students' worldview assumptions will be instructionally more effective, and that can be tested. In sum, there is in worldview theory significant, potential explanatory power.

A Research Agenda

In worldview theory the primary assumption that must be made is that worldview variations exist in the typical classroom. Using a thematic approach to world view, one might question such an assumption. The sensitivity and richness of Kearney's worldview model, however amply justifies this expectation of variation. The question then becomes, do these variations actually exert a significant influence on science achievement and attitude? To answer that we must first be able to identify students with these variations. This points to an initial avenue of science education research with respect to worldview theory.

Worldview research in science education must begin by defining the parameters of a scientifically-compatible world view. In other words, one must identify the assumptions and attributes in the seven universals that are of importance to science. This is not a philosophical question about the nature of science. Rather, the question is, what does science require of students' fundamental belief and thought structures? For example, what assumptions and attributes concerning causality should students have, or about time or space?

The answer to this question or at least a partial answer would allow one to address the problem of identifying students with worldview variations vis-a-vis a scientifically-inclined world view. At that point one could test the effect of such variations on science

achievement and attitude. A positive result would lead the researcher to the development and assessment of worldview-based, instructional strategies. It would also open other issues. What worldview assumptions need not be supplanted, given that they can be linked with worldview assumptions necessary for science? "God as a causal agent" is an example. On the other hand, what assumptions block science understanding? What assumptions cannot be linked to a modern understanding and appreciation of science?

Earlier in the paper it was mentioned that there are gender and ethnic differences in science achievement and attitude. These differences could be subjected to a worldview analysis. Given the different backgrounds of students, it may be found that many women, Hispanics, Blacks have significant worldview variations vis-a-vis white, male students. I suspect that an analysis of scientifically-compatible worldview variations will show that the worldview variations of women, Blacks and Hispanics are not incompatible with science, only with the way science is often taught.

There are other important questions such as how worldview theory and Piagetian theory can be integrated? Since worldview development is a long dialectical process, questions about early childhood and elementary level teaching strategies arise. The worldview universals imply a broader definition of science at these early levels. For example, the development of the concept of time is likely to be an important science objective for some children, though this is not now a common part of science instruction. And then there is the area of misconception research. Much of this could be reexamined in the light

of worldview theory. One important question is, are there key conceptions symptomatic of worldview variations?

In sum, the science education researcher interested in worldview theory must first be able to describe a scientifically-compatible world view (at least in part), and then be able to distinguish between students with and without such a world view. Only then can one address the question of worldview variation as a factor in science achievement and attitude. The specific research questions I have posed here are only a beginning, but ultimately the value worldview theory as a research framework in science education rests on the fruitfulness of research directed by these fundamental questions.

PART II

The Development of an Instrument for Distinguishing Science-Related Variations in the Causal Universal of College Students' World Views

The primary assumption one makes in worldview theory is that the world views of students in any typical classroom vary. There is in other words, significant heterogeneity. Using a thematic approach to world view such as Pepper's root metaphors (1942), one might question such an assumption. The sensitivity and richness of Kearney's logico-structural model of world view, however amply justifies this expectation of variation (Cobern 1988, Kearney 1984). The question then becomes, do these variations actually exert a significant influence on science achievement and attitude? To answer that we must first be able to identify students with these variations. This paper first reports on the development of an instrument for distinguishing science-related variations in the Causal Universal of college students' world views; and then reports the results of an examination of worldview variation as a factor in science interest.

Worldview research in science education begins by asking what worldview assumptions and attributes, in which universals correspond with our understanding of the nature of science and science attitudes. In other words, one asks for the parameters of a scientifically-compatible world view. In this study I limited my attention to one aspect of a scientifically-compatible world view, i.e., the Causal Universal of a world view. Second, I chose to work with college freshmen instead of secondary students both as a matter of logistical convenience, and to minimize confounding factors such as reading ability. This study was very much a pilot project in that it was a first attempt at research derived from worldview theory based on the Kearney logico-structural model (Cobern 1988, Kearney 1984). It is my hope that the results of this study will be found supportive of worldview theory as an important factor in science education research.

Research Method

Undoubtedly, there are many ways one could use to distinguish worldview variations among students. My approach was to develop a paper-and-pen instrument that could be given to a large number of students in a short period of time. The instrument is intended to be a preliminary discriminating device used prior to more incisive, investigative techniques, probably techniques of the ethnographic type. The content of the instrument derives from the contention that a scientifically-compatible world view must include assumptions in the Causal Universal that are appropriate to scientific explanation.

The primary problematic feature of any instrument designed to discriminate among students according to worldview variations is that the instrument itself must not be a test of scientific knowledge. As explained in an earlier paper on worldview theory in science education research (Cobern 1988, pp.8-10), being ignorant of scientific concepts does not necessarily indicate a worldview variation. With regard to distinguishing variations in the Causal Universal, this can be avoided by making the following assumption:

> When a student is faced with an unfamiliar phenomenon, he or she is more likely to accept an explanation that is more consistent with his or her worldview than an explanation of the phenomenon that is less consistent.

If we present a student with an unfamiliar phenomenon and two explanations, one cast in a scientific style and the other not, we would expect students with scientifically-compatible worldviews to choose the first explanation more frequently than students with variant world views. This suggests that an effective instrument could be constructed with "unfamiliar phenomena" as items.

Instrument Development

The construction of such an instrument has four parts: identifying unfamiliar phenomena to be used in the items, establishing criteria for a scientifically compatible explanation, testing the items for discrimination capacity, and finally, establishing an instrument scale. The problem with identifying unfamiliar phenomena is that one never knows who is familiar with what. One way around the problem is to create fictitious or quasi-fictitious phenomena. For the current study, 28 fictitious and quasi-fictitious phenomena were created. The only criterion was that the phenomena be plausible. The original instrument contained items based on these 28 phenomena, plus three more items based on factual, but obscure phenomena. The instrument instructions indicated that the items did not necessarily contain factual information, and therefore was not a test of knowledge.

The research assumes that assumptions amenable to scientific explanations are present in a students world view if a student frequently chooses explanations that are scientifically-compatible. In this research a scientifically compatible explanation was needed for each item. Obviously the explanations for the fictitious phenomena would be fictitious. The explanations for the obscure phenomena items also needed to be fictitious in order to avoid confounding affects of students who might happen to be knowledgeable about the obscure phenomena. The criteria for designing a fictitious, but scientifically compatible explanation came primarily from Braithwaite's book Scientific Explanations.

According to Braithwaite, an explanation and hypothesis are virtually the same thing. To be acceptable in science they must be

empirical and above all, testable. A scientific explanation or hypothesis always involves natural causes and tends to be mechanistic and reductionistic. The key terms are:

1. natural
2. rational,
3. mechanistic/reductionistic,
4. hypothetical/deductive,
5. experimental,
6. epistemologically dynamic/tentative.

Any scientific explanation is also a part of a theoretical structure or system composed of many explanations, generally on different levels of explanatory power. Scientific explanations are generally not given in isolation. With the exception of one item which relates experimentation to theory, all of the items in the instrument contain ad hoc explanations. However, the notion that explanations should be related to other explanations in an explanatory system is not unique to scientific thinking, and therefore was not included as a criterion for the items in this instrument.

The foil in each item was an explanation designed to be scientifically-less compatible or simply scientifically unacceptable. The criteria for authoring such explanations were basically the opposite of the above terms with the exception of "rational." An attempt was made to write reasonable explanations that were non-testable, non-mechanistic, and wholistic rather than reductionistic. The 31 items in the original instrument were primarily written by the author. Two physicists and a mathematician offered useful expert, editorial advise plus suggestions for items.

The Selection of Items

Having compiled and edited 31 items, the next step was to test their discriminating power. This was done by giving the instrument to subjects identified as having a strong or weak scientifically-oriented world views, and retaining only the items that discriminate between the two groups. Scientists and engineers comprised the former group. The group assumed to have weak, scientifically-oriented world views were primarily non-science students at the University of Sokoto, Nigeria. The second assumption was deemed sound because these were students raised in a non-scientific, non-technological society who at the university level still had professed little interest in science. The second group also included female secretaries at two American colleges who professed little science interest. The demographics of this group was such that one would expect them to have much less of a scientific orientation than a group of scientists.

The test was constructed in three, 31 item formats. In format A, each item contained a phenomenon description followed by two explanations of opposing style. One explanation was cast in a scientifically-more compatible style and the other in a scientifically-less compatible style. In formats B and C, the descriptions were followed by one explanation and a five-point scale of "acceptability." The instructions to participants called the instrument a survey, rather than a test, and indicated that the instrument did not call for technically "correct" responses. In Format A, the subjects were to choose the one explanation of the two that they found more acceptable. In Formats B and C, they were to indicate on the scale how acceptable they found the single explanation.

The item selection basis for inclusion in the final instrument was a "0.4" minimum difference between the science and non-science groups. For example, if on an item 80 percent of the science professors choose the scientifically-more compatible explanation but only 40 percent of the students choose this explanation, then the item was retained.

In the first analysis, 12 of 31 items were retained. Four other items that I initially predicted to be very good discriminators, in fact did not get the anticipated response from the scientists and engineers. Subsequently, these four items were given to a science professor who had not participated in the first study. Based on his comments about how he would answer the items, I dropped one. The other three were modified and retained. The final instrument dubbed "TOPE," Test of Preferred Explanations, contained seventeen items. Fifteen of these came from format A, and only two from formats B and C.

Having come to these items through the process described above, it was my contention that scores on this instrument would show a positive relationship with science interest, because the instrument would indicate the scientific-compatibility of an important aspect of a college student's world view. If among typical college students, worldview variation is not a significant factor in science interest, then there should be no relationship (although it could be argued that the failure to show the anticipated relationship was the fault of the instrument rather than the theory).

Therefore, TOPE was given to 120 freshmen at Austin College in the Fall of 1987. These students were enrolled in a required freshman course and represented just under half of the freshman class. As an

indicator of science interest the students were asked which majors most interested them and which were of least interest. The two questions were combined and scored as 1, 0.5, or 0. To further assess the validity of the instrument, copies of TOPE were sent to 200 scientists randomly selected from the American Scientific Affiliation directory. Of these 88 usable, completed tests were returned (44%). Based on the student scores, the test-retest reliability was calculated to be 0.81. Three null hypotheses were tested:

> There is no significant difference between the TOPE scores of scientists and the TOPE scores of students with high science interest.
>
> There is no significant difference between the TOPE scores of scientists and the TOPE scores of students with low science interest.
>
> There is no significant difference between the TOPE scores of students with high science interest and the TOPE scores of students with low science interest.

The hypotheses were tested using a oneway ANOVA procedure (Walonick 1986). The results are given in Tables 1, 2, and 3.

The Group Means of
Scientists and Students

Cell Definition	N	Mean	SD
Students w/ No sci interest	35 (16.8%)	9.74	2.43
Students w/ Some sci interest	36 (17.3%)	10.38	1.74
Students w/ Sci interest	49 (23.6%)	11.40	2.08
Professionals	88 (42.3%)	12.36	2.06
	208 (100%)		

TABLE 1

Anova Summary Table

Source of Variation	DF	Sum of Squares	Mean Squares	F	Significance Level
Sci Interest	3	214.1421	71.3807	16.4476	0.0000
Error	204	885.3374	4.3399		
Total	207	1099.4796			

Table 2

****
****

T-Test Between Cell Means
(Values of p are for a two-tailed test)

No sci interest vs. Some sci interest	N/S
No sci interest vs. Sci interest	t = 3.5899 p = 0.0004
No sci interest vs. Professionals	t = 6.2816 p = 0.0000
Some sci interest vs. Sci interest	t = 2.2370 p = 0.0264
Some sci interest vs. Professionals	t = 4.8112 p = 0.0000
Sci interest vs. Professionals	t = 2.5853 p = 0.0104

TABLE 3

Summary of Results

The three null hypotheses were rejected at $p =< 0.01$. The expected order of results was confirmed. The mean score for professional scientists was highest followed by the mean score of students with high science interest. The students with low science interest had the lowest mean score on TOPE. The method used to gauge science interest was a cursory one at best. Yet because the results were positive, one would expect to find even greater differences with science interest measured by a more sophisticated instrument.

The group mean for scientists is lower than expected. One factor to consider is that the scientists in the study were largely from liberal arts colleges. As such they may be more open to different explanation styles than research scientists at research universities. Another possibility is that the lower than anticipated scores indicate a lack of instrument sensitivity. Redoing the study using a group of research scientists at research universities would help to answer the question.

The process of test development appears to have been successful. Overall, the results of the study with scientists and students are in line with what worldview theory predicts, and thus support the theory. The results also lend specific support to the contention that worldview variations significantly influence science interest. Furthermore, the results indicate that this avenue of research is worth pursuing.

SURVEY OF PREFERRED EXPLANATIONS

Instructions:

In the following pages you will find a series of paragraphs each describing a fictitious event or phenomenon. Each paragraph is followed by either one or two explanations of what is in the paragraph. Do not think of the explanations as either correct or incorrect. In fact none of the explanations are necessarily correct. This is a survey of the kind of explanations people find more convincing when they hear about something of which they know very little.

Use the answer sheet for recording your answers. For the items with two explanations choose "A" or "B" according to which explanation you would be more willing to accept. For the items with one explanation choose a rank according to how acceptable you find the given explanation.

ANSWER SHEET

Circle only one answer per item. Avoid choosing "?" as much as possible. Use it only when you absolutely cannot decide between "A" and "B".

1.	1	2	3	4	5
2.	1	2	3	4	5
3.	A	?	B		
4.	A	?	B		
5.	A	?	B		
6.	A	?	B		
7.	A	?	B		
8.	A	?	B		
9.	A	?	B		
10.	A	?	B		
11.	A	?	B		
12.	A	?	B		
13.	A	?	B		
14.	A	?	B		
15.	A	?	B		
16.	A	?	B		
17.	A	?	B		

ITEM 1

Reports from a recent space flight indicate a new material has been identified in outer space. Although insensitive to the presence of ordinary matter, when approached by a human being it glows brightly in a variety of colors.

It has long been suspected from other evidence that human beings give rise to psychic emmanations, but the main difficulty has always been the development of a suitable detector for this influence. This new material appears to be an ideal detector for it is sensitive to human proximity as well as operating over a wide range of personality types.

How acceptable is this explanation to you? Select the appropriate rank below:

1. completely acceptable with no objections or reservations.
2. very acceptable with few objections or reservations.
3. acceptable but with some objections or reservations.
4. somewhat acceptable but with several objections or reservations.
5. not acceptable.

ITEM 2

Recently astronomers have observed an increase in radio wave activity of particular frequency from a particular sector in the sky. This observation has caused a stir and a great deal of speculation as to its explanations. So far most astronomers accept the following explanation:

> Man has often doubted that he was alone in this vast universe. These radio waves might well be radio signals from some far civilization upon which we have stumbled or indeed they may even be meant for us.

How acceptable is this explanation to you? Select the appropriate rank below:

1. completely acceptable with no objections or reservations.
2. very acceptable with few objections or reservations.
3. acceptable but with some objections or reservations.
4. somewhat acceptable but with several objections or reservations.
5. not acceptable.

ITEM 3

Some people were observing a demonstration that involved a miniature red train car, a bit of track, and a tunnel. When the demonstrator pushed the train car into the tunnel a blue car came out the opposite side. When the demonstrator pushed the blue car back into the tunnel, the red car reappeared out the other side. People suspected there were really two cars, originally the blue one being hidden by the tunnel. To test this idea they listened carefully when the red car was pushed into the tunnel feeling sure that they would hear it knocking the blue car out the opposite side. Try as they might, they could hear no sound of a collision. The people then fell into two groups over the matter. Which explanation below would you be more willing to accept? Choose "A" or "B".

Explanation A:

Some people found the demonstration intriguing and amusing. They considered the demonstrator to be a kind of magician who was proving that the hand really is quicker than the eye.

Explanation B:

Other people recalled that like-poles of magnets repel each other. So perhaps there were two cars each with a magnet. Like-poles faced each other so that one car entering the tunnel drove the other out without the two ever touching.

If you absolutely have no preference for one over the other, mark "?".

Item 4

There once was a woman who, to put it mildly, drank a great deal. Every day after work she would begin going from bar to bar until late in the night. Hardly a day would pass that she did not end in a state of intoxication. People said this was not even the worst of her moral degeneracy, but that she was as well a cruel and spiteful woman. She seemed to delight in unkindness. One morning she did not come to work. Later it was learned that she died the night before of a heart attack. Her colleagues at work had two opinions about her fate. Which one would you be more willing to accept? Choose "A" or "B".

Explanation A:

As the doctors said, she died of a heart attack. She undoubtedly put too much physical strain on her system and her heart finally gave way.

Explanation B:

She was a young woman who should have had many years ahead of her. She was, however, decadent and mean, and an untimely death was the consequence.

If you absolutely have no preference for one over the other, mark "?".

ITEM 5

Occasionally when entering a room for the first time a person gets the distinct impression that he has been there before. This impression can be very strong and disturbing, and all the more because one is sure that he has not ever seen the room before. There seems to be two reasonable explanations for this phenomenon. Which explanation below would you be more willing to accept? Choose "A" or "B".

Explanation A:

This is an example of deja vu which is something almost all of us experience from time to time. It is remembering a place you have never been to before or an object or person you have never seen before. This phenomenon is a reminder of the vast complexity of the human mind, a complexity of which we understand very little. What we understand least is the capacity of the mind to perceive things outside the range of our basic physical senses.

Explanation B:

The human brain is a complex electro-chemical computer. Although for the most part it functions faultlessly, there are occasional lapses. The above is such a case. After the first glimpse of the room, there is an instantaneous functional lapse and recovery. The lapse separates the initial glimpse from the current perception of the room. The result is that the initial glimpse becomes like a memory. A person is deceived into thinking that he has seen the room before.

If you absolutely have no preference for one over the other, mark "?".

ITEM 6

Two men became tired of working for their living so they decided to rob a bank to make themselves rich. They took guns, went to a local bank and demanded all the money. An alert policeman saw what was happening and intervened. The robbers fearing capture fired their guns. In the confusion they managed to escape in a stolen car leaving behind several injured and dying people. By this time the robbers were panic stricken and raced down the road at a very high speed. On a curve the driver lost control of the car and both of them died in a ghastly accident. Among the people who read about this incident in the newspapers there seemed to be two feelings about why these robbers died. Which explanation below do you find more acceptable? Choose "A" or "B".

Explanation A:

Why did these men die? We may be glad that they did die being so evil. The "how" however, is more simple. They poorly planned their evil deed. Had they carefully thought it all out ahead of time they either would have abandoned the idea or would have developed a much less reckless plan.

Explanation B:

Sometimes we look around and see the evil that people get away with, and we think to ourselves, "There is no justice." But often there is justice and here is a good example. These men willfully decided to do evil. Why did these two die? It was the just price of their evil.

If you absolutely have no preference for one over the other, mark "?".

ITEM 7

In the past when a person's heart stopped beating he was declared dead. Now medical doctors have the technology to restart a person's heart if they act quickly enough and thus to bring him back to life. A curious result of this is that we are now receiving interesting reports from these patients who have "died" but have been saved by this new technology. These reports are about the experiences these people have had during the minutes when their hearts were not beating. They claim that during that time they experienced the afterlife, that is the life that many people believe to be waiting for a person after he dies. There have been two reactions to these claims. Which explanation below would you be more willing to accept? Choose "A" or "B".

Explanation A:

The dreams of a sleeping man are due to various electro-chemical processes in the brain. When a man's heart stops beating these brain processes do not immediately stop as well. His mind may still be dreaming since it takes time for this electro-chemical activity to cease. If the doctors are able to revive a man's heart, then when he regains consciousness what he remembers are only dreams like any other.

Explanation B:

We may say that a man has died when his heart stops beating. What we really should say is that his body has died. The spirit of the man still lives just as the philosophers have so often taught. The reports from these people who have died and then been revived give us the first empirical evidence that the spirit of a man does not die with his body.

If you absolutely have no preference for one over the other, mark "?".

ITEM 8

In many areas of the world today the health of the people is looked after by traditional and herbal medicine practitioners. These traditional physicians practice a healing art based on generations of accumulated knowledge. In spite of this, the modern study of medicine does not include any areas of this traditional knowledge. Recently doctors concerned about this issue have divided into pro and con groups. Which position below would you be more willing to accept? Choose "A" or "B".

A: PRO-POSITION

The study of modern medicine is the study of western medicine. This should tip us off to the real reason behind the resistance to the scientific study of traditional herbal medicine. It is pure and simply western chauvinism. From the scientific point of view there is no reason for not carefully researching well-documented traditional cures. The findings would benefit all of mankind; and in addition there would be a greater appreciation of the traditions of non-western peoples.

B: CON-POSITION

Modern experimental medicine has been successful largely because it is directed by rational theory. The theoretical structure of a science tells the investigator which avenues of experiments are most likely to be profitable, thus avoiding many dead-ends. Since there is no such structure in traditional medicine a researcher would have to follow dozens, even hundreds of vague accounts of "cures that work." Such ad hoc experimenting is wasteful and inefficient. It is for this same reason that researchers do not investigate the "home cures" that are used by so many families.

If you absolutely have no preference for one over the other, mark "?".

ITEM 9

A startling discovery has recently been made amongst a pre-modern group of people in a remote region of the Amazon Basin. An anthropologist living with these people for a year noted that the council of elders had a perfect record on predicting rainy days. Out of 365 days there were 109 days on which rain began to fall. All of these days were correctly predicted two to four days in advance. For the same period of time the government meteorological forecasts were much less accurate. The elders based their predictions upon the pattern made by dried chicken bones which they would cast a specific number of times each day. The elder's accuracy impressed the scientist but he was skeptical that the bones had much to do with it. He therefore got the elders to cooperate in a number of experiments by which he hoped to determine the real nature of their predictions. These experiments confirmed none of his hypotheses, all were rejected. In the end he was convinced that the predictions must indeed rest upon the chicken bones. Later the anthropologist reported his findings at a symposium; and although his peers agreed with his conclusions they disagreed in their reasons. Which side do you find more acceptable? Choose "A" or "B".

Side A:

One side noted that pre-modern people, although pre-modern are still clever. They skillfully put to use the collective observations and knowledge of their ancestors, as in this case where a people are able to predict weather by observing bone patterns. Modern people are surprised by this achievement only because they think of the pre-modern person as naive and unintelligent.

Side B:

The other side noted that chemists have long known that dry bones absorb moisture from the air. The amount of "bounciness" in a bone likely depends on how much moisture has been absorbed; thus there is a possible link between bone-bounciness and weather conditions.

If you absolutely have no preference for one over the other, mark "?".

ITEM 10

Pea seeds when passed through a magnetic field germinate faster than seeds which are not passed through a magnetic field. There appears to be two logical explanations for this. Which explanation below would you be more willing to accept? Choose "A" or "B".

Explanation A:

The magnetic field has an effect on the pea seed chromosomes. This results in faster cell division due to the pre-alignment of the chromosomes by the magnetic field. The seeds therefore germinate quicker.

Explanation B:

After fertilization there is a principle of life which begins to drive the growth process. At an early stage that principle can be stimulated and quickened by many outside forces such as a magnetic field.

If you absolutely have no preference for one over the other, mark "?".

ITEM 11

When plant seeds are grown in small pots it is possible to quicken their growth rate by periodically shaking the pots. This "shaking effect" is poorly understood but there are two schools of thought on the matter. Which explanation below would you be more willing to accept? Choose "A" or "B".

Explanation A:

The roots of plants use up first the nutrients in the soil which are closest. The result is that the amount of soil nutrients increases with distance from the roots. Shaking stirs up the soil and helps bring richer but distant soil into contact with the roots.

Explanation B:

All living things benefit from an occasional but gentle stirring up of their environment, and even of themselves. It gets the juices, fluids and chemicals moving and flowing. It provides fresh air and removes the stale. It encourages, one might say, the processes of life.

If you absolutely have no preference for one over the other, mark "?".

ITEM 12

Bird migrations are an interesting phenomenon. For instance some geese can fly thousands and thousands of kilometers from one point on the earth to another never getting lost. This remarkable feat of navigation is of great interest to biologists and also controversial. There are two much debated explanations. Which explanation below would you be more willing to accept? Choose "A" or "B".

Explanation A:

Some biologists view bird navigation as a kind of natural movement. For instance, humans can both walk and crawl; but they always walk because that is what is natural for them to do. It is possible for geese to fly in the wrong direction but that would be like humans crawling. They do not do it because it is unnatural.

Explanation B:

Some biologists are quite convinced that wind currents act like Coriolis forces on the birds. The geese are sensitive to very slight variations in wind force and direction. By instinct they react to these variations and thus maintain their course.

If you absolutely have no preference for one over the other, mark "?".

ITEM 13

Is it logically possible for a system to explain itself? It appears to be a circular dilemma since to explain itself a system can only explain in terms of itself. For instance is it possible to know how the brain really works since any theory put forward by scientists is a product of the human brain? . The dilemma seems very discouraging yet many scientists are undetered. Should we be optimistic or pessimistic about this kind of research? Which of the positions below would you be more willing to accept? Choose "A" or "B".

Position A:

The key to understanding any system, no matter how complicated, is in its parts. The parts are usually less complicated than the whole. By examining and experimenting with the parts we eventually will learn enough about the whole brain to enable us to restore all neurological disorders.

Position B:

Science has enjoyed great progress in understanding natural phenomena and scientists as a result have come to take progress as a scientific right. They have lost sight of the fact that all human endeavors including progress are limited and unending progress is not to be expected. If neuro-scientists were to remember that then their present viewpoint on the human brain would certainly be more humble.

If you absolutely have no preference for one over the other, mark "?".

ITEM 14

eople often wonder when confronted by the human-like characteristics of chimpanzees why they have not evolved the ability for language and speech. Opinion on this issue is divided. Which explanation below would you be more willing to accept? Choose "A" or "B".

Explanation A:

The thoughts and emotions of a chimp are simple, lacking complexity, and can be communicated to another chimp by simple means, e.g. gestures. On the other hand an elaborate capacity for speech is required by humans because of their equally elaborate structures of thought and emotion. Simple means of communication would just not be sufficient.

Explanation B:

Appearance can be deceiving as in the case of human-like characteristics of chimpanzees. The primary distinction between other animals and human beings is the "humanity" of man which is composed of such abilities as speech and rational thought. Without "humanity" man would indeed be just another animal.

If you absolutely have no preference for one over the other, mark "?".

ITEM 15

A goal that geologists have long had is to acquire enough knowledge about earthquakes so that they can be anticipated hours or even days in advance. Recently it was discovered that many animals can do just that. The geologists are still unsure about just how a particular animal senses a quake coming but there are two theories. Which theory below would you be more willing to accept? Choose "A" or "B".

Theory A:

There are many things in the environment that animals sense such as danger or changes in the weather. This is an ability that modern people have lost due to their remoteness from nature and reliance upon technology.

Theory B:

It has now been learned that there are slight almost imperceptible pre-tremors that come hours, sometimes days before a major quake. These pre-tremors are noticed by animals particularly grazing animals, which then become quite nervous.

If you absolutely have no preference for one over the other, mark "?".

ITEM 16

Astronomers have found that certain planetary bodies appear to deviate slightly from their calculated position in space. The deviation is extremely small. Everyone working in this field agrees:

a. that the deviation exists (i.e. it is real), and
b. that Relativity Theory offers the most likely explanation.

When asked why they supported this explanation workers were found to be divided. Which explanation below would you be more willing to accept? Choose "A" or "B".

Explanation A:

It is difficult to make accurate measurements and existing experimental evidence lends only weak support for the theory. Nevertheless, the evidence gives better support to this theory than to any other.

Explanation B:

The explanation was published by one of the most distinguished scientists of the 20th century. There is no doubt that he knows more than anyone else in the world about this particular phenomenon.

If you absolutely have no preference for one over the other, mark "?".

ITEM 17

A physicist at a well known university was conducting a unique set of experiments. He was interested in the effect of electrical discharges on the growth rates of a particular type of tree. The methodology was simple. He administered electrical shocks to one set of trees but not to a second. Over a period of several months he measured and compared the growth rates of the two groups. The scientist's work caused a stir among his colleagues because he admittedly had no theoretical framework for his research. There were two basic opinions about this kind of experimentation. Which opinion below would you be more willing to accept? Choose "A" or "B".

Opinion A:

The highly theoretical nature of physics provides an ample number of research problems for experimental work. Theory guided research is more efficient because there is a greater chance of success. This man has picked an idea out of thin air and pursued it for no other reason than idle curiosity.

Opinion B:

This man should not be criticized for his unique albeit different research problem. All too often progress in many fields is thwarted by over-conservatism and rigid adherence to theory. Independence from theory should be encouraged so that more discoveries can be made and the understanding of nature increased.

If you absolutely have no preference for one over the other, mark "?".

_____ GENDER: M F

NAME

If the following were your only choices for a college major, which one or two areas would you <u>most likely</u> choose as a major? Check one or two areas.

_____ art/music

_____ science

_____ English

_____ political science

_____ history

_____ business/economics

If the following were your only choices for a college major, which one or two areas would you be <u>least likely</u> to choose as a major? Check one or two areas.

_____ art/music

_____ science

_____ English

_____ political science

_____ history

_____ business/economics

For the purpose of my research I would like to compare your scores on this instrument with your SAT/ACT scores and Myers-Briggs results. The information will be kept strictly confidential. If I may have your permission to obtain your SAT/ACT and Myers-Briggs results from the College files, please sign here:

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